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## RESEARCH ON FLUID METERS, PARTICULARLY FLOW NOZZLES

Over a year ago the subcommittee on the use of nozzles, orifices, and venturis of the American Society of Mechanical Engineers' committee on power test codes, requested the society's special research committee on fluid meters to furnish it with authoritative information on the designs in use, methods of using, and the constants of fluid meters employed as head meters for testing power-plant equipment, such as turbines, fans, and blowers.

On carefully considering the problem, the fluid meters' committee felt that, while it had available sufficient information on orifice meters, more data were needed on flow nozzles and to a certain extent on venturis. The committee, therefore, decided that a research program should, if possible, be undertaken on flow nozzles and venturis, to be tied in, wherever feasible, with orifices. The following conditions, however, were laid down:

1. That the program, if undertaken at all, should be sufficiently thorough

and of wide enough range to insure real value of the results for many years.

2. That the planning and coordination of the tests, regardless of where they might be made, and the correlation of the results should be under the immediate direction of one person.

3. That existing plant facilities (including personnel) should be utilized as far as possible, so as to keep the cost of the work down and to insure a wide range of conditions.

It was likewise felt that if the results were to be of maximum value the tests should be made with pipe ranging from about 1 or 2 inches to 16 inches in diameter; the ratios used should range from about 0.1 to about 0.85; and, as far as possible or desirable, the tests should be made with water, steam, and air. Also, each differential producer should be tested over a Reynolds' number range of at least 1 to 5.

Assuming that a research program of this extent could be carried through, H. S. Bean, chief of the gas measuring instruments section of the Bureau, was

asked to undertake its direction, in accordance with recommendation 2.

In order to comply with the third recommendation it was necessary to collect information on the facilities available. To this end a circular letter was sent by Mr. Bean to those organizations believed to have suitable facilities, such as universities, electric utilities companies, natural gas companies, and meter, engine, and compressor manufacturers. The questions asked were the following:

1. Are you making any tests on flow nozzles or venturis at the present time?

2. If so, would you be willing to make the results of such tests available to the fluid meters' committee so that they may be included and correlated as a part of the committee's program?

3. If the answer to 2 is affirmative, will you give an outline of your test program?

4. What equipment and facilities do you have that might be made available to the committee for making some of the tests proposed:

- (a) Tests with water;
- (b) Tests with steam;
- (c) Tests with air?

In answering give information as to the size and maximum lengths of straight pipes that could be obtained, the source of the fluid flow, the approximate range of rates of flow, and the facilities for weighing the discharge when water or steam is used as the fluid.

5. To what extent would members of your staff be able to assist in any tests that might be made at your plant?

6. Have you suggestions as to the conditions that should be covered by the committee in this program of tests?

The following brief summaries indicate the gratifying nature of the replies received:

Public Service Co. of New Jersey, Essex Generating Station, can make tests with water, using 6- to 16-inch pipe, 40,000 to 650,000 lb/hr., up to 600-ft head. Has two scale tanks, capacity 11,000 lb, net, each.

University of California, Department of Mechanical Engineering, can make tests with water, using pipe up to 8-inch diameter; flows up to 3.4 ft<sup>3</sup>/s. Has a volumetric tank with a capacity of 400 ft<sup>3</sup>.

Bailey Meter Co., can make tests with water, using 2- to 6-inch pipe (inclusive); flows up to 2,000 gallons per minute; 50-ft head. Has a volumetric tank and a V-weir.

General Electric Co., Lynn Plant, can undertake work on steam and air, using 2- to 6-inch pipe; steam flows up to 25,000 lb/hr. Has suitable condenser and weighing tanks.

Buffalo Forge Co., can make tests using air, with pipe sizes up to 36 inches at low pressures; flows up to about 8 ft<sup>3</sup>/s.

Favorable replies have likewise been received from the Massachusetts Institute of Technology, Ohio State University, the University of Pennsylvania, and others. The Bureau, itself, will work with water, air, and steam, for the most part using the facilities available in its hydraulic laboratory. Some funds are now available, and it is expected that enough more will be contributed to make possible carrying out the program practically along the lines originally laid down. Diameter ratios from 0.10 to 0.85 in at least 4 and possibly 7 sizes of pipe from 2 to 16 inches in diameter will probably be used. Each differential producer will be tested with water in one or more of the laboratories named. Check tests will be made using air and steam on from one-third to one-half the total combinations. Definite plans have been made covering tests of nozzles and taps and also for certain subsidiary tests.

It is expected that the program will require about 3 years for completion.

#### FUSIBLE TIN BOILER PLUGS

The general rules and regulations of the Bureau of Navigation and Steamboat Inspection of the United States Department of Commerce require that the boilers of all steam vessels under the jurisdiction of the Bureau shall be provided with fusible plugs as a safety measure. These fusible plugs consist of a bronze casing the tapered bore of which is filled, from end to end, with pure tin. The plugs are required to be inserted into the boiler shells, tubes, or flues, depending upon the type of boiler, so that the end of the tin filling on the water end of the plug is not less than 1 inch above the dangerous low-water level of the boiler. The plugs are intended to function as pressure-relief valves when the temperature within the boiler rises above the melting point of the tin filling. The melting point of pure tin is 232° C (449° F).

The regulations provide that the manufacturers of such plugs furnish, for examination and test, one sample from each lot of 250 plugs, or fraction thereof, and that no plugs of any lot shall be distributed for use until a

certificate of approval has been obtained from the Bureau of Navigation and Steamboat Inspection.

The examinations and tests of the samples submitted are made by the National Bureau of Standards for the Bureau of Navigation and Steamboat Inspection. Chemical analysis of the tin filling is made to determine whether the purity of the tin conforms to the requirements of the regulations, which prescribe that the tin shall contain not more than 0.50 percent of copper, and not more than 0.10 percent each of lead and zinc; or not more than 0.70 percent of total impurities.

Although it is possible to obtain tin of higher purity than that prescribed above, it has been found that a certain amount of contamination of the tin in the filling by the metal of the casing is unavoidable if the plugs are properly manufactured according to the regulations. It has been found also that satisfactorily constructed plugs will function in the desired temperature range if the tin of the filling does not contain impurities in excess of the amounts specified.

The plugs are examined also to determine that the tin fillings are metallically bonded to the casings and that the bores of the casings are tapered uniformly and smoothly from end to end. A recess in the bore of the casing, designed to hold the filling when it is not metallically bonded to the casing, is not permitted.

The following publications from the National Bureau of Standards describe studies, made over a period of years, of various problems concerned with the manufacture and testing of fusible boiler plugs.

(1) An investigation of fusible tin boiler plugs. G. K. Burgess and P. D. Merica. Tech. Pap. BS 15 (1915) T53; (2) Tin fusible boiler plug manufacture and testing. Trans. Am. Inst. Min. Met. Engrs. 64, 227 (1920); and (3) Reliability of fusible tin boiler plugs in service. J. R. Freeman, Jr., J. A. Scherrer, and S. J. Rosenberg. BS J. Research, 4, 1 (1930) RP129.

#### CHEMICAL REACTIONS IN THE LEAD STORAGE BATTERY

Although battery engineers have generally accepted the double-sulphate theory of chemical reactions in the lead storage battery, its validity has often been questioned because of disagreement between the theory and certain experimental results. Experimental difficulties in proving the theory have doubtless accounted for the

variety of results previously obtained. The chief difficulty lies in determining how much electrolyte, including that in the pores of the plates, is contained in the cell. This difficulty was overcome in a recent investigation at the Bureau, reported in the April number of the Journal of Research (RP778), by using the so-called method of mixtures. If a solution of known concentration, but unknown weight, is mixed with a carefully weighed portion of water or another solution differing in concentration, and the concentration of the resulting mixture determined, it is possible to calculate accurately the weight of either the original or final solution. This method, which has not previously been applied to this problem, has many advantages and has enabled the authors to determine not only the number of equivalents of acid used per faraday (96,500 coulombs) but also the number of equivalents of water formed. The results of this new series of measurements are entirely consistent with the double-sulphate theory in showing that two equivalents of acid are used and two equivalents of water are formed for each faraday of electricity. No evidence of the anomalous substances postulated by some previous experimenters was found.

#### CURRENT TRANSFORMERS

Commercial measurements of electric power and energy, in circuits carrying alternating currents of large value, are invariably made by the use of current transformers which supply, to the measuring instruments proper, secondary currents which are a replica to a reduced scale of the corresponding currents in the primary circuit. In important installations the proportionality factor or "ratio" of the transformer is obtained by an experimental comparison between the transformer in question and a standard transformer of known ratio. This comparison is usually made in the testing laboratory of the utility company concerned, while the standard transformer in turn is tested at suitable intervals by some "absolute" method in a large standardizing laboratory such as that of the Bureau.

It is evident that the accuracy of the final results would be invalidated if the conditions under which either the working or the standard transformer is operated were allowed to differ to a significant extent from the conditions under which either transformer was tested. With ordinary care

such conditions as frequency and secondary burden can be reproduced with sufficient fidelity. However, the geometrical configuration of the primary conductors near a transformer cannot always be reproduced. As reported in RP775 in the April Journal of Research, the variations in proportionality factor caused by changes in the location of the primary conductors were determined experimentally for transformers of various makes and designs with primary current ratings from 1,200 to 7,500 amperes. The results indicate that the error in proportionality factor thus introduced may be rather large.

#### DEFINITIONS OF POWER, POWER FACTOR, AND RELATED QUANTITIES

Electrical energy is now one of the important articles of commerce and problems connected with its generation, transmission, and distribution are taxing the ingenuity of experts. In discussing these matters, it is important for all engineers to use the same language. However, in the complex conditions that have arisen, a group of engineers has frequently adopted a jargon which could not be understood by those even in nearly related fields. An effort is being made by the American Institute of Electrical Engineers to remedy this condition. In a paper published in the April number of Electrical Engineering, the Bureau has endeavored to amplify and clarify the definitions that have been prepared for the various power quantities which are connected with the rate of flow of energy in alternating-current circuits.

The definitions of the power quantities for a simple circuit with the most ideal type of alternating current are universally accepted. However, as the circuit becomes more complex or as the alternating current departs from the ideal, an extension of the definitions is required and new quantities, with their definitions, must be introduced. This paper outlines the principles by which these extensions can be made, and suggests names for all the required quantities.

#### RECENT STUDIES OF THE IONOSPHERE

RP780 in the April Journal of Research presents and interprets data accumulated as a result of weekly measurements of the ionosphere made over a period of 18 months. (See Technical News Bulletin 215, March 1935.) A general discussion of the theoretical aspect of three major lay-

ers of the ionosphere, E, F<sub>1</sub>, and F<sub>2</sub>, is given. Typical diurnal curves of the variation of the E and F<sub>2</sub> critical penetration frequency for three seasons are shown. Particular attention to the relation of their critical frequencies and the ionizing force of the sun is stressed.

A seasonal variation of the F<sub>2</sub> critical has been found with maxima appearing about November 1 and March 1. Absence of F<sub>2</sub> criticals above 5,000 kc/s during summer midday, possibly because of a transfer of ions from the F<sub>1</sub> to the F<sub>2</sub> layer, is obvious.

A general discussion of a "sporadic E" layer is given. This layer appears with a pulse retardation approximately that of the E layer but for much higher frequencies. Energy from this layer is believed to be returned by reflection rather than refraction. A comparison of sporadic E reflections and thunderstorms in and near Washington is tabulated.

A region returning energy from a greater virtual height than the F<sub>2</sub> layer and appearing after the F<sub>2</sub> critical has passed, has been tentatively called the G layer. Its peculiarities are discussed.

#### INFRARED SPECTRA OF THE NOBLE GASES

Among all the chemical elements, the noble gases, helium, neon, argon, krypton, and xenon, are in some respects the most interesting. The outer structure of each of these atoms consists of a "closed shell" of electrons. This gives the atoms exceptional stability, accounts for their chemical inertness, and characterizes them with spectra which extend over an extraordinary range of wave lengths reaching from the extreme ultraviolet to the far infrared. These spectra are of special interest because of what they disclose about atomic structure, and also on account of practical use which has been made of them in spectroscopy, metrology (as a standard of length), and illumination (advertising signs, etc.). The best method of studying the details of a spectrum is to photograph the dispersed light. This was easy for blue and ultraviolet light, but until recently was impossible for the longer waves because of the lack of sensitiveness of photographic materials for these radiations. A method of sensitizing photographic emulsions to longer waves was discovered 60 years ago, but improvements came very slowly. Thirty years ago it was still impossible to photo-

graph visible red. Ten years later the known photosensitizers permitted the first attack on the adjacent infrared. In recent years the discovery of new dyes by the Research Laboratory of the Eastman Kodak Co., has resulted in the most remarkable advances in infrared photography. New types of plates recently produced enable the spectroscopist to photograph nearly an entire octave of infrared spectra. Application of a new plate to the spectral investigation of noble gases at the Bureau has revealed several hundred new radiations, all of which confirm the earlier deductions about the structure of these atoms. These results are given in detail in the April Journal of Research (RP781).

#### ARC SPECTRUM OF COPPER IN THE INFRARED

One of the problems of the Bureau's spectroscopy laboratory is to furnish as complete descriptions of the spectra of the chemical elements as modern observational methods will permit. For the element copper, radiometric observations made elsewhere several years ago failed to reveal any lines in its arc spectrum in the range from 8100 to 12000 Å, a region now readily explored with the new types of photographic plates that are sensitive to infrared light. A new photographic survey of this spectral region has now been completed at the Bureau with the result that nearly 30 new lines have been discovered. All of them, except one, are accounted for as combinations between terms derived from an analysis of the previously known arc spectrum of copper. For a complete report RP783 in the April number of the Journal of Research should be consulted.

#### PRECISE PRISM REFRACTOMETRY

The use of air as a standard reference medium, and the degree of precision attainable in precise refractive index determinations on various transparent materials, have been investigated in the optical instruments' section of the Bureau and a report (RP776) will be published in the April number of the Journal of Research. All published values for the refractivity of air, and also for the varying effects of its temperature, pressure, and humidity have been considered in the preparation of correction tables which are recommended for the accurate reduction of observed refractive-index

data to standard conditions of reference.

With regard to the transparent materials themselves, the direct effect of temperature on refractivity is discussed, and an equation is given for computing (from published compressibilities) the approximate effect of pressure on the refractivity of liquids. For optical glasses, a new (empirical) relationship between index and density is derived from Pockels' data on the index changes produced by elastic deformation, and this relation is used in computing atmospheric-pressure effects on glass. A basis for the quantitative treatment of permissible stress-birefringence in optical glasses is given. Also, the character of annealing and the permissible degree of striation in optical glasses are briefly considered.

The requisite constancy in the wave length of light emitted by a source is evaluated for refractive-index determinations on several media including carbon disulphide and flint glass of highest refractive and dispersive powers.

Tolerance equations corresponding to individual errors of  $\pm 1 \times 10^{-6}$  in refractive index are given for all working conditions and requirements that are quantitatively discussed. After reviewing similar tolerances given in former papers, it is considered feasible to measure or control all conditions within such limits. In conclusion, it is estimated that an accuracy of 2 or 3 parts in a million can be expected in measurements by the classical method of minimum deviation, provided care and reasonably good equipment are used.

#### A TURBULENCE INDICATOR UTILIZING THE DIFFUSION OF HEAT

While wind-tunnel turbulence is receiving ever-increasing recognition as an important factor in wind-tunnel tests, its evaluation is by no means common practice in aerodynamic laboratories. This is largely because a turbulence determination is attended with more difficulty and uncertainty than is the average aerodynamic measurement.

In an attempt to find some simple method of determining turbulence, its effect upon the diffusion of heat from an electrically heated wire of small diameter in an air stream was investigated. The turbulence of the stream was introduced by a series of geometrically similar screens placed separately across the up-stream section of the tunnel. With the wire set at various distances from the screens, curves of

temperature distribution were obtained by traversing the heated wake at a distance of 2 inches behind the wire with a small thermocouple connected to a sensitive galvanometer. From these curves the width at half maximum was selected to represent the width characteristic of the wake. A single relation was found to exist between the width, so defined, and distance in screen wire diameters from the several screens.

One purpose of the work was to correlate the widths with percentage turbulence as measured by the more complicated "hot-wire" method. Since no single relation exists between percentage turbulence and distance in screen wire diameters from the same series of screens, the correlation could be represented only approximately by a single curve.

#### EVOLUTION OF HYDROGEN SULPHIDE FROM RUBBER DURING VULCANIZATION

The evolution of hydrogen sulphide from rubber during and subsequent to vulcanization has been dealt with previously. See BS J. Research 4, 501 (April 1930) RP162, and 9, 163 (August 1932) RP164.) Further work has shown that the quantity of hydrogen sulphide evolved is dependent on its concentration in the rubber.

This is demonstrated by two vulcanization experiments, which were con-

ducted with a stock consisting of fine Para rubber, 68 parts, and sulphur 32 parts, by weight. In one experiment a weighed sample was cured in a vulcanizing press at 148° C (298° F) in the form of a sheet about 1 mm thick and 250 mm in diameter. The sample was protected by aluminum plates so that only the 1-mm edge was exposed to the air. The sample was removed from the press at intervals and weighed, along with the aluminum plates which adhered to it. A relatively small and progressive loss in weight was observed, which, on the basis of other work, was taken as being all hydrogen sulphide. At the conclusion of the experiment the aluminum plates were stripped off and the sheet of hard rubber was heated in air at 95° C (203° F) under a fan for one-half hour to drive off any hydrogen sulphide dissolved in the rubber. The loss in weight resulting from this treatment was only 0.025 percent of the weight of the sample.

In another experiment a sample of the same stock was extruded in a layer about 1 mm thick on no. 12 aluminum wire. Vulcanization was conducted at 148° C in a stream of inert gas, and the hydrogen sulphide determined by absorption in alkali as in Research Paper RP464.

The results of the two experiments are given in the following table:

Time (hours)	Total hydrogen sulphide evolved		(Time (hours)	Total hydrogen sulphide evolved	
	Sample in press	Sample in stream of inert gas		Sample in press	Sample in stream of inert gas
	Percent	Percent		Percent	Percent
1.....	0.003	0.031	26.....		1.85
4.....	.020	.47	32.....	0.099	
11.....	.030		40.....	.188	
22.....		1.58	47.....	.295	
25.....	.045		50.....		3.06

A comparison of the second and third columns of this table indicates that much less hydrogen sulphide is evolved when hard rubber is vulcanized even in a partially inclosed space than when it is vulcanized in a stream of gas in which the hydrogen sulphide is swept away as fast as it is formed.

#### RELATION OF INK TO THE PRESERVATION OF WRITTEN RECORDS

As part of its studies on the preservation of valuable records, the Bureau has investigated the part that ink

plays in the deterioration of written manuscripts. Inked specimens of several types of paper were subjected to an accelerated aging test that has been useful for obtaining, in the laboratory, effects similar to years of natural aging. This test is made by heating samples in an oven for 72 hours at a temperature of 100° C., and comparing the number of times a treated and an untreated sample can be folded without breaking. The papers are folded in a machine made for this purpose.

Inks of several kinds, and solutions of their separate ingredients, were ap-

plied to paper and tested in this way. The acid writing inks were found to hasten the deterioration of writing papers to an alarming degree, and several constituents were found to contribute to the harmful effects. The greatest apparent damage was done to record papers of the highest grades. A type of ink made with the compound known as ammonium ammoniumoxyferrigallate (Technical News Bulletin 202, February 1934) was found to be only slightly detrimental to the paper. A more complete account of this work appears as RP779 in the April number of the Journal of Research.

#### BUSY YEAR PLANNED FOR PAPER SECTION

With the assistance of funds from other Government agencies and from outside organizations, the Bureau plans to expand the research activities of its paper section during the ensuing year.

A new project recently initiated is a study of the possible effect on papers, of fumigating gases used to rid written and printed materials of destructive insects. This was undertaken at the request of the National Archives and with their financial assistance. Another investigation which will take the section into a new field is concerned with the stability of prints on motion-picture films. This form of record material has assumed great importance; librarians, educators, and others interested in the spreading and preservation of knowledge are deeply interested in the possibilities of film records. With the assistance of a fund granted for the purpose to the National Research Council by the Carnegie Foundation, it is planned to make a year's study of the resistance of the film records to various degrees of temperature, humidity, and light. It is hoped that this work can later be expanded into a comprehensive study of the many other problems concerning miniature records, and of problems related to sound recordings.

Direction of and participation in the standardizing activities of the T. A. P. P. I. paper testing committee will be continued. The committee has developed 37 standard testing methods and has 14 additional ones under development at the present time. An attempt will be made to produce a device for measuring in numerical terms the rate of failure of printed currency under conditions which result in appearance

and loss of strength similar to those caused by actual service wear. This work is supported by the U. S. Treasury Department.

One of the continuous jobs of the paper section, and of the Bureau in general, is the development of the technical requirements of United States Government purchase specifications. This involves service as committee members and sometimes research to secure technical information not available. The standardization project on lithographic papers will be continued through at least a part of the year. This work has resulted in three publications relating to improvement of register in successive color prints, and another will be issued in the near future. Extension of the work in this field is planned if sufficient funds become available for it.

While the experimental paper mill can be operated only intermittently (with the limited personnel available the mill operatives must not only make the papers but also test them) it is hoped that progress can be made in studying the relation of the papermaking materials, both fibrous and non-fibrous, to the stability and strength of book papers. This will complete the general program of work of this kind related to the preservation of records, as similar studies of writing papers have been made.

#### THE TESTING OF PAPER

In an address before the Delaware Valley Section of the Technical Association of the Pulp and Paper Industry in Philadelphia on March 22, F. T. Carson of the Bureau outlined the two-fold scope of paper testing; its use in manufacturing control, and its use in appraising the finished product. The essential differences in viewpoint of manufacturer and consumer were developed, as well as the factors in common. The requirements made by each group for testing instruments is different, said Mr. Carson, and he illustrated this point by specific examples. Out of the differences in viewpoint have grown an uncoordinated system of testing, vague definitions, and loose terminology that provide a fertile field for the extension of standards in the interest of a common language and better understanding.

Laboratory tests are intended to tell us in a very short time whether or not a material will serve its intended use. This determines the conditions of the test and requires that it be well-planned and carefully thought out to

give a faithful indication of the property in question.

While precedent should be used as much as practicable, paper has certain unique properties that require special treatment, and present certain problems.

Mr. Carson outlined some guiding principles in analyzing a testing problem and approaching its solution. The general property must be broken up into unit properties which can be evaluated. Examples were given to illustrate the approach and the working out of methods of measuring the unit properties.

#### WATER RESISTANCE OF PAPER

The application of ultraviolet light to determine when water has permeated through paper in the measurement of its water resistances is described by Julius Grant in the November 2, 1934, issue of the *Journal of Chemical Industry*. After an examination of the various means proposed for this purpose, he decided that the dry-indicator method originally developed by F. T. Carson, of Bureau, and further improved and adopted as a standard testing procedure by the Technical Association of the Pulp and Paper Industry, was superior to the many other methods proposed for the purpose. The dry-indicator test consists of sprinkling a mixture of water-soluble dye, sugar, and starch on the surface of paper, floating the paper on water with the dye mixture on the upper surface of paper, and noting the time of water permeation as indicated by development of the dye color. As the color usually develops rather slowly and in spots, the end point is rather difficult to determine. Grant observes the dye mixture on the floated paper in a dark room in ultraviolet light, and he states that at first nothing can be seen, since the powder does not fluoresce and the paper is almost covered, but the first sign of penetration is indicated by the almost instantaneous appearance of a bright golden fluorescence resulting from the solution of the dye. He further states that the change is very striking and leaves no doubt as to the end point.

#### PAPERMAKING QUALITY OF CORNSTALKS

Paper from cornstalks would cost more than papers made from wood according to the results of recent studies made at the Bureau. This

work was undertaken to find just what the possibilities are for converting a part of this farm waste into paper. It was found possible to make clean, white, writing paper despite serious difficulties presented by the structural characteristics of the plant, and by the excessive amounts of dirt always clinging to field-gathered stalks. However, from a consideration of the costs, it does not appear that cornstalks can compete successfully with wood as a raw material for paper under present conditions.

Special mechanical preparation of the stalks was found essential to successful pulping with chemicals, owing to structural peculiarities of the type of plant stem. The hard outside part of the stem contains the bulk of the fibers of suitable length for paper, and the most satisfactory results in pulping were obtained by using only this outside shell or cortex. The cortex was separated from the pith and shredded by special mechanical processes.

The cornstalk fibers were found to be too brittle for use in ordinary brown wrapping papers where strength is the prime requisite, and although satisfactory writing papers were made, the yields were very low. The results indicated that less than half as much paper can be made from a ton of stalks as from an equal weight of wood. Also, cornstalks are so light and bulky that much more pulping equipment and chemicals are required than for wood. From a consideration of all of the costs involved in making paper from cornstalks as compared with wood, it is estimated that the stalks could not compete successfully with wood, even if wood were to double in price, unless profitable uses are developed for byproducts or parts of the stalk not used in paper.

These studies are fully reported in Miscellaneous Publication M147, copies of which are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents each.

#### DETERMINING FINE CONSTITUENTS OF SAND

A recent publication of the Bureau (J. Research NBS 14, 59 (Jan. 1935) RP757, described a new method for determining the fine constituents of a foundry sand which are too small to be determined by the sieving methods generally used. This new method is an adaptation of the sedimentation method. An unsuspected application

for this method has recently arisen in connection with the study in the hydraulic laboratory of the transportation and deposition of sediment by rivers. Preliminary tests have given very promising results.

#### WEATHERING OF CLAY BRICK

Clay brick has long been noted as one of the most durable of the commonly used structural materials. Occasionally, however, a few of the bricks in a wall or other structure are markedly affected by weathering. There is a common belief among builders and manufacturers that well-burned brick are durable and that the "salmon" brick are the only ones which may disintegrate when exposed. This belief appears to be justified by experience and by the results of laboratory tests. Unfortunately, however, it does not provide a positive criterion for judging the probable durability of a product. A method is, therefore, needed for selecting bricks that will weather well.

Before laboratory results can be accepted as an accurate guide to the probable durability of bricks, it is necessary to obtain comparisons between the effects of natural weathering and the data obtained from laboratory tests. A few such comparisons have been made at the Bureau.

Clay bricks which had been exposed in the walls of buildings for 6 to 17 years were removed and then subjected to various physical tests and to laboratory freezing and thawing tests. Each brick was broken transversely. One of the halves was then subjected to freezing and thawing tests during which the appearance of the unweathered face was frequently compared with the weathered face of the reserved half to determine how many cycles would produce the same amount of decay as the actual exposure. Fourteen new bricks also were subjected to the laboratory tests. The observations indicated that about 3 cycles of freezing and thawing caused an effect which appeared to be similar to that of 1 year of exposure in the walls. The ratio of absorption by 48-hour cold immersion to that after 5 hours in boiling water (C/B ratio) was a fair criterion for judging the durability of the bricks. None of those having a C/B ratio less than 0.8 were visibly affected by exposure to the laboratory weathering tests; and none having a C/B ratio less than 0.89 showed a marked effect of weathering while in the walls of buildings.

#### GRANULOMETRIC COMPOSITION OF CEMENT

Although a great deal of work has been done in other laboratories to determine the effect of fineness of grinding of cement on the properties of neat pastes, mortars, and concretes made therefrom, nevertheless there has not been enough data available to allow many broad generalizations other than that fineness of grinding is an important factor in determining the rate of increase in strength, and that there is urgent need for further study. Therefore, an investigation has been undertaken at the Bureau with the hope of clearing up some of the controversial issues. In this study six different cements were separated into size fractions, and studies were made of the individual fractions as well as four different blends of them.

It was found in the study of the different fractions that the finest material in a cement, such as that of diameter less than 7 microns, is very valuable because of the plastic qualities which it confers upon the concrete mixes and also because of the large contribution which it makes to the early strength. Materials of sizes larger than 7 microns were found to be increasingly deficient in plasticity; a 7 to 22 micron fraction was not vastly different from an ordinary cement, while a fraction of material greater than 55 microns in diameter behaved very much like a fine sand. The strengths of mortar briquettes and concrete cylinders made from four fractions of material coarser than 7 microns were found to decrease with increasing grain size, or to increase with increasing specific surface, at all ages tested.

Four cements blended from the fractions in varying proportions so as to have specific surfaces ranging from 1,350 to 3,300  $\text{cm}^2/\text{g}$  developed strengths directly related to the specific surface at all ages. The neat pastes of these cements, on the average, required an amount of water for normal consistency almost directly related to the specific surface. The time of initial set as determined by the Gillmore needle was found to be inversely related to the specific surface.

A more thorough analysis of the strength data tended to prove that the compressive strength of concrete is very nearly a direct function of the amount of cement which has become hydrous. No direct measurements of the rates of reaction were made, but a

function of size distribution was found which could logically be expected to represent the amount of cement which had become hydrous and which did yield values proportional to the strengths of the fractions and also those of the blends. When the compressive strengths were plotted against specific surface, one line was obtained for the blends and another for the fractions, but when they were plotted against the supposed hydrous material, only one line was obtained.

The contribution of the 0 to 7 micron fraction to the compressive strengths of the blended cements was calculated by an algebraic method based on the assumption that the contribution of any fraction to the strength of a blended cement is equal to the product of the decimal part of the blend composed of that fraction and the strength of the fraction when tested by itself. The calculated values were of the order which might have been expected, and it is believed that they indicate the actual worth of the fine material much more closely than values determined by testing the fraction alone with the low cement-water ratio which was required by the fine material.

A complete report of the work on this problem will be presented in RP777 of the Journal of Research for April.

#### EFFECT OF CALCIUM CHLORIDE ON PORTLAND CEMENTS AND CONCRETES

During the past 2 years a fellowship had been maintained at the Bureau for studying the reaction of calcium chloride on portland cement and its constituents. A progress report on the reaction of calcium chloride on portland cement, by Paul Rapp and Lansing S. Wells, giving the results of short-time tests of calcium chloride on certain physical properties of cement and concrete, was published in the Proceedings of the Thirteenth Annual Meeting of the Highway Research Board 13, part 1, 291 (Dec. 1933).

The long-time tests have now been completed and a final report of the investigation will appear as RP782 in the April issue of the Journal of Research under the title, Effect of calcium chloride on portland cements and concretes, by Paul Rapp. A paper by the same title will also appear in the Proceedings of the Fourteenth Annual Meeting of the Highway Research Board, and will contain an appendix giving the complete data. Data are presented in these papers giving the effect of calcium chloride on the heat of hydration, setting time, strength, and

consistency of a selected group of cements. From measurements of temperature rise of a given amount of cement and water during the first 24 hours the quantity of heat evolved was calculated. The heat contributed by the individual compounds and the influence of calcium chloride on this heat was computed. The addition of calcium chloride appears to increase somewhat the heat contributed by dicalcium silicate and tetracalcium aluminoferrite and to decrease the heat contributed by tricalcium aluminate. There is little change in the heat contributed by tricalcium silicate when calcium chloride is added. Calcium chloride increases the rate at which the heat is evolved by all cements tested. A study of a large number of experimental cements showed that the addition of calcium chloride increased the strength contributing factors of the two calcium silicate compounds and decreased the strength contributing factor of tricalcium aluminate. The effect of calcium chloride on the strength contributing factor of tetracalcium aluminoferrite is not readily apparent. The setting time of 11 commercial cements, together with the spread of the time of set of these cements, was decreased as the amount of calcium chloride was increased. With each cement the flow, as determined with a flow table, was increased by the addition of calcium chloride. Calcium chloride added to mortar and concrete not only greatly accelerated the early strengths, but appreciably increased the 1-year strengths. These same effects were produced by the addition of calcium chloride to the 60 experimental cements. The optimum amounts to be added for different types of cement and at various curing temperatures is indicated.

#### NEW AND REVISED PUBLICATIONS ISSUED DURING MARCH 1935

##### Journal of Research<sup>1</sup>

Journal of Research of the National Bureau of Standards, vol. 14, no. 3, March 1935 (RP nos. 766 to 774, inclusive). Price 25 cents. Obtainable by subscription.

<sup>1</sup> Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and the Republic of Panama); other countries, 70 cents and \$3.25, respectively.

Research Papers<sup>1</sup>

[Reprints from the November and December 1934 and January 1935 Journal of Research.]

RP740. Polymerization of olefins formed by the action of sulphuric acid on methylisopropylcarbinol. G. M. Kline and N. L. Drake. Price 5 cents.

RP743. Calibrations of the line standards of length of the National Bureau of Standards. L. V. Judson and B. L. Page. Price 5 cents.

RP751. Photoelastic properties of soft, vulcanized rubber. W. E. Thibodeau and A. T. McPherson. Price 5 cents.

RP754. Fatigue properties of steel wire. S. M. Shelton and W. H. Swanger. Price 5 cents.

RP755. Interference measurements in the infrared arc spectrum of iron. W. F. Meggers. Price 5 cents.

Simplified Practice Recommendations<sup>1</sup>

R155-34. Cans for fruits and vegetables. Price 5 cents.

Miscellaneous Publications<sup>1</sup>

M147. Paper-making quality of cornstalks. C. G. Weber, M. B. Shaw, and M. J. O'Leary. Price 5 cents.

Technical News Bulletin<sup>1</sup>

Technical News Bulletin No. 215, March 1935. Price 5 cents. Obtainable by subscription.

<sup>1</sup> Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, \$2.50 per year (United States and its possessions, Canada, Cuba, Mexico, Newfoundland, and the Republic of Panama); other countries, 70 cents and \$3.25, respectively.

LETTER CIRCULARS

It is the intent of the Bureau to distribute single copies of these Letter Circulars on request only to those parties having special interest in the individual Letter Circular. Economy necessitates limitation in the number of copies issued. It is not the intent to supply parties with a copy of each Letter Circular issued during the month. Letter Circulars are necessarily of a temporary nature designed to answer numerous inquiries on a given subject. Requests should be addressed to the National Bureau of Standards.

LC437. Methods of using standard frequency radio emissions. (Supersedes LC404.)

LC438. Sources of radio information. (Supersedes LC400.)

OUTSIDE PUBLICATIONS<sup>1</sup>

Preparation, use, and abuse of specifications for paint materials. P. H. Walker. Preprint, American Society for Testing Materials (260 South Broad St., Philadelphia, Pa.), (March 1935).

Analysis of mixtures of textile fibers. R. T. Mease. Am. Dyestuff Reporter (440 Fourth Ave., New York, N. Y.), 24, 94 (February 25, 1935).

The manufacture of hosiery and its problems. E. M. Schenke, research associate. Book, published by the National Assn. Hosiery Manufacturers (468 Fourth Ave., New York, N. Y.), (March 1935).

A study of the system lime-potash-alumina. L. T. Brownmiller. Paper no. 30, Portland Cement Association Fellowship (National Bureau of Standards, Washington, D. C.), (March 1935).

Laboratories in the stratosphere. Lyman J. Briggs. The Scientific Monthly (Grand Central Terminal, New York, N. Y.), 40, 295 (April 1935).

<sup>2</sup> These publications are not obtainable from the Government. Requests should be sent direct to the publishers.



